5.17.06 USING RANDOM NUMBERS

(a) Scope.

This method covers procedures for securing random samples from a lot by the use of random numbers obtained from tables or generated by other methods.

(b) Definitions.

(1) Lot: An isolated or defined quantity of material from a single source, or a measured amount of construction assumed to be produced by the same process. Specified amounts of asphalt concrete mix, a stockpile of aggregate or linear feet of roadway constructed in a day are examples of a Lot.

(2) Sublot: A portion of a Lot. When it is not convenient to sample the entire Lot, such as a specified amount of hot mix, then it can be divided into equal sized sublots. The sublots, when combined, would constitute the entire Lot.

(3) Random: Without aim or pattern, depending entirely on chance alone (Not to be construed as haphazard).

(4) Sample: A small part of a Lot or a sublot which represents the whole. A sample may be made up of one or more increments or test portions.

(5) Random Number: A number selected entirely by chance. Random numbers may be generated electronically such as with a random number function on a calculator or spreadsheet or selected from a table of random numbers (See **Table 1**).

(c) Use of random numbers in sampling.

Most sampling and testing for construction materials should be randomized to prevent any unintentional bias of the results. Randomization of sampling times or locations is accomplished by using a set of random numbers to determine the time or location for the sample. Consult the appropriate specification for details on lot sizes, sublots, frequency of sampling and other details. Methods for selection of random numbers are included below.

(1) Example 1: Determining when to sample.

As an example assume ten trucks carrying equal loads are going to be used to deliver concrete during a bridge deck placement. Select which truck to sample for compressive strength cylinders to be molded.

Generate a random number using one of the methods below. Use .456 in this example. Multiply .456 by 10 (the number of trucks) for a result of 4.56. Round this result to a whole number, 5 in this case. Take the concrete sample from the fifth truck.

This method can be used to select a time of day or the day of the week also. If production was to occur during an 8 hour day, multiply 8 by the selected random number, .456, to obtain a result of 3.648. If rounding is used the sample should be taken in the fourth hour of production. Refinement could be used to select a time down to the nearest

minute if need be by using the integer, three in this case, as the hour and then multiplying the decimal by 60 to obtain the minute, 60 x .648 or +/- 39 in this case. Sampling would occur three hours and thirty nine minutes into production. Use the number seven multiplied by a random number to determine a day of the week.. Sampling during production according to units, such as tons of material produced, can be handled in the same fashion. Multiply the lot or sublot size, as required, by the random number selected.

(2) Example 2: Determining location for sampling.

Given random numbers selected:

X	Y
.338	.922
.763	.198
.043	.737
.810	.747

ENGLISH EXAMPLE:

Sampling of a large lot may require division into sublots to insure all portions of a lot are represented. Stratification into sublots is accomplished by dividing the "Lot" material (in this case, a mile of construction or 5280 feet) into "four sublots" (each of 1320' or 1/4 mile).

To locate a sample point station in sublot no. 1, the length of that sublot is multiplied by the "X" coordinate for that "sublot" and the product added to the beginning station for that sublot.

Starting Station = 486 + 15	486 + 15
$(X_1)(1320) = (0.338)(1320) = 446'$	4 + 46
Sample Station =	490 + 61

The sample point distance from the base line (generally center line or the edge of pavement) is determined by multiplying Y_1 by the available width.

Y_1 (12'6") = 0.922 (12.5') = 11.5' from Base Line.

Thus the sample location is Sta. 496 + 61, 11.5' from Base Line. Keeping in mind that the second sublot begins at station 499+35 (sta. 486+15 + 1320'), the second, third and fourth locations are determined by the same technique. These values are:

Sublot #2 Sta. 509 + 42, 2.5' from Base Line.
Sublot #3 Sta. 513 + 12, 9.2' from Base Line.
Sublot #4 Sta. 536 + 44, 9.3' from Base Line.

SI EXAMPLE:

Stratification into sublots is accomplished by dividing the "Lot" material (in this case, 2,000 meters) into "four sublots" [each 500 meters (2,000/4) long]

To locate a sample point station in sublot no. 1, the length of that sublot is multiplied by the "x" coordinate for that "sublot" and the product is added to the beginning station for that sublot.

Starting Station = 1+525	1 + 525
$(X_1)(500) = (0.338)(500) = 169$ meters	169
Sample Station =	1 + 694

The sample point distance from the base line (generally center line or the edge of pavement) is determined by multiplying Y_1 by the available width.

$(Y_1)(3.7\text{ m}) = (0.922)(3.7) = 3.4$ m from Base Line

Thus the sample location is Sta. 1 + 694, 3.4m from Base Line. Keeping in mind that the second sublot begins at station 2 + 025 (sta. 1 + 525 + 500m), the second, third, and fourth locations are determined by the same technique. These values are:

Sublot # 2 Sta. 2 + 406.5, 0.7 m from Base Line.
Sublot # 3 Sta. 2 + 546.5, 2.7 m from Base Line.
Sublot # 4 Sta. 3 + 430, 2.8 m from Base Line.

(d) Methods for selection of random numbers.

(1) Use of calculators or spreadsheet functions.

Many calculators have a random function. Review the manual for a given calculator to determine how to access this function. Sets of random numbers may be generated directly from the calculator by repeated use of this function.

Most spreadsheets also have a function to generate random numbers. Insert the random number function into a cell and press enter. A random number will be generated. Copy that cell as needed to produce the required quantity of random numbers. It may be necessary to reformat the cells to have only three decimal places. Read the manual for the specific spreadsheet for more detail on use.

Note: The District Materials Engineer may require a different method of generating random numbers to be used if an electronic method is determined to not be truly random.

(2) Use of the Random Number Table (Table 1).

Use of the random number table requires the use of “seed” numbers to provide starting points for selection of the random numbers. A seed number can be obtained by several methods including odometer readings, generation by a random number function of a calculator or spreadsheet or by “pointing” if necessary.

Using an odometer reading such as 37864.2 as a seed number use the digit farthest to the right (2) to select the column in the table and the next two digits, counting from right to left, (64) to select the row. If the seed number for the column is 0, use column 10 and if the seed for the row is 00, use row 100. In this case finding the intersection of the row and the column yields the number .338. Use this as a starting position and count down the column for the required number of samples. Selecting numbers for an X coordinate for three samples yields .338, .763 and .043. If a Y coordinate is also required use the fourth digit from the right for the column and the next two digits, counting from right to left, for the row. In this example that would yield column 8 and row 37 producing a starting point at number .922. If a total of three samples are required, counting down two more places yields numbers .198 and .737. Using this example, pairs of numbers for determining three X and Y coordinates are obtained, (.338, .922), (.763, .198) and (.043, .737). Any amount of numbers required may be selected this way. If ten samples are required count down the column until ten numbers are selected. Once the bottom of a column has been reached go to the top of the next column to the right and count down to obtain more numbers, if the bottom of column 10 is reached go to the top of column 1. Use of the odometer to generate seed numbers is not recommended if more than one set of X and Y pairs of random numbers is required in a relatively short period of time due to the slow change of the left odometer numbers.

Seed numbers maybe obtained by using the random number function of a calculator or spreadsheet. In the above example the same results would have occurred if a calculator returned .264 for the first seed number. Use the first digit (2) to select a column and the second two digits (64) for the row. If using the random number function again produced .837, then the same numbers would have been generated for the Y coordinate as in the above example.

Seed numbers may be obtained by "pointing" also. Lay copies of both pages of Table 1 side by side and with eyes closed place a pointer on the Table to select a seed number. Use this number as in the above example. Suitable pointers would be any device with a small tip such as a pin or a mechanical pencil.

RANDOM NUMBERS **TABLE 1**

	1	2	3	4	5	6	7	8	9	10
1	0.293	0.971	0.892	0.865	0.500	0.652	0.058	0.119	0.403	0.234
2	0.607	0.840	0.428	0.857	0.125	0.143	0.562	0.692	0.743	0.306
3	0.161	0.182	0.544	0.646	0.548	0.384	0.347	0.330	0.869	0.958
4	0.856	0.103	0.019	0.990	0.370	0.094	0.967	0.642	0.332	0.717
5	0.779	0.795	0.262	0.276	0.236	0.537	0.465	0.712	0.358	0.090
6	0.036	0.475	0.100	0.813	0.191	0.581	0.350	0.429	0.768	0.574
7	0.028	0.569	0.915	0.344	0.009	0.523	0.520	0.521	0.002	0.970
8	0.442	0.320	0.084	0.623	0.859	0.608	0.714	0.937	0.559	0.943
9	0.045	0.878	0.108	0.876	0.466	0.117	0.005	0.912	0.150	0.887
10	0.625	0.906	0.957	0.145	0.616	0.606	0.279	0.207	0.337	0.242
11	0.962	0.457	0.424	0.102	0.462	0.885	0.710	0.352	0.617	0.781
12	0.938	0.696	0.085	0.916	0.844	0.281	0.254	0.528	0.470	0.267
13	0.431	0.960	0.653	0.256	0.944	0.928	0.809	0.543	0.739	0.776
14	0.755	1.000	0.072	0.501	0.805	0.884	0.322	0.235	0.348	0.900
15	0.139	0.365	0.993	0.091	0.599	0.954	0.693	0.249	0.925	0.637
16	0.064	0.040	0.219	0.199	0.055	0.732	0.105	0.505	0.661	0.579
17	0.701	0.450	0.950	0.218	0.067	0.531	0.979	0.783	0.934	0.096
18	0.659	0.406	0.800	0.525	0.339	0.936	0.719	0.029	0.825	0.215
19	0.804	0.580	0.754	0.690	0.629	0.794	0.841	0.131	0.388	0.168
20	0.261	0.456	0.158	0.774	0.673	0.289	0.982	0.371	0.666	0.121
21	0.604	0.471	0.020	0.870	0.624	0.349	0.426	0.529	0.634	0.214
22	0.587	0.083	0.635	0.038	0.767	0.473	0.939	0.647	0.449	0.691
23	0.947	0.292	0.217	0.183	0.366	0.172	0.156	0.570	0.583	0.185
24	0.351	0.025	0.224	0.432	0.752	0.636	0.664	0.582	0.622	0.213
25	0.165	0.184	0.516	0.099	0.353	0.920	0.097	0.519	0.197	0.126
26	0.725	0.931	0.309	0.436	0.782	0.389	0.707	0.297	0.709	0.803
27	0.253	0.506	0.656	0.343	0.974	0.898	0.162	0.879	0.393	0.231
28	0.498	0.414	0.576	0.427	0.662	0.345	0.877	0.385	0.122	0.051
29	0.104	0.301	0.346	0.905	0.918	0.572	0.838	0.092	0.282	0.260
30	0.035	0.075	0.518	0.280	0.115	0.611	0.362	0.062	0.578	0.567
31	0.503	0.421	0.697	0.610	0.147	0.049	0.545	0.452	0.852	0.497
32	0.274	0.205	0.778	0.472	0.245	0.951	0.671	0.932	0.713	0.731
33	0.314	0.032	0.468	0.493	0.252	0.833	0.812	0.445	0.904	0.324
34	0.400	0.422	0.592	0.854	0.832	0.527	0.605	0.797	0.089	0.455
35	0.807	0.593	0.989	0.997	0.910	0.722	0.645	0.534	0.021	0.327
36	0.118	0.377	0.711	0.871	0.024	0.251	0.433	0.814	0.577	0.216
37	0.007	0.288	0.372	0.727	0.014	0.259	0.037	0.922	0.460	0.230
38	0.476	0.011	0.265	0.188	0.317	0.603	0.981	0.198	0.853	0.977
39	0.275	0.700	0.745	0.535	0.179	0.902	0.706	0.737	0.133	0.748
40	0.721	0.237	0.283	0.070	0.644	0.614	0.942	0.747	0.123	0.880
41	0.980	0.716	0.819	0.079	0.526	0.071	0.828	0.536	0.463	0.909
42	0.359	0.789	0.135	0.555	0.394	0.444	0.775	0.269	0.510	0.845
43	0.733	0.598	0.059	0.921	0.816	0.381	0.454	0.477	0.596	0.250
44	0.192	0.968	0.430	0.699	0.295	0.383	0.266	0.401	0.542	0.286
45	0.354	0.799	0.004	0.232	0.633	0.682	0.638	0.897	0.485	0.695
46	0.496	0.012	0.243	0.985	0.355	0.612	0.315	0.760	0.392	0.541
47	0.494	0.113	0.773	0.867	0.824	0.976	0.323	0.134	0.761	0.911
48	0.780	0.687	0.318	0.202	0.331	0.264	0.670	0.848	0.114	0.495
49	0.023	0.027	0.930	0.031	0.843	0.730	0.919	0.858	0.866	0.360
50	0.086	0.335	0.631	0.247	0.120	0.965	0.675	0.999	0.601	0.948

Table continued next page.

Table 1 Cont.

	1	2	3	4	5	6	7	8	9	10
51	0.940	0.312	0.994	0.564	0.946	0.886	0.016	0.112	0.169	0.241
52	0.547	0.336	0.382	0.017	0.836	0.632	0.175	0.053	0.441	0.821
53	0.376	0.620	0.399	0.765	0.618	0.203	0.530	0.124	0.132	0.326
54	0.586	0.268	0.109	0.378	0.434	0.734	0.551	0.894	0.464	0.321
55	0.018	0.409	0.539	0.144	0.703	0.180	0.478	0.688	0.929	0.674
56	0.588	0.227	0.896	0.758	0.826	0.504	0.512	0.026	0.863	0.481
57	0.305	0.689	0.137	0.319	0.558	0.418	0.277	0.992	0.766	0.447
58	0.831	0.899	0.208	0.698	0.676	0.195	0.808	0.759	0.738	0.439
59	0.626	0.827	0.959	0.440	0.411	0.861	0.850	0.686	0.159	0.374
60	0.201	0.895	0.480	0.270	0.369	0.407	0.082	0.749	0.057	0.435
61	0.030	0.167	0.509	0.419	0.508	0.181	0.490	0.875	0.830	0.482
62	0.136	0.065	0.416	0.116	0.907	0.556	0.095	0.110	0.395	0.736
63	0.591	0.600	0.405	0.657	0.013	0.651	0.225	0.340	0.146	0.155
64	0.487	0.338	0.170	0.006	0.263	0.173	0.228	0.008	0.010	0.313
65	0.364	0.763	0.391	0.790	0.589	0.003	0.998	0.257	0.984	0.437
66	0.996	0.043	0.793	0.522	0.705	0.248	0.924	0.609	0.639	0.423
67	0.063	0.810	0.189	0.769	0.488	0.152	0.221	0.978	0.329	0.229
68	0.513	0.333	0.540	0.160	0.461	0.683	0.285	0.750	0.557	0.311
69	0.176	0.054	0.341	0.484	0.860	0.046	0.278	0.244	0.222	0.864
70	0.549	0.835	0.398	0.829	0.459	0.153	0.728	0.822	0.106	0.756
71	0.298	0.514	0.945	0.648	0.784	0.154	0.499	0.415	0.397	0.255
72	0.888	0.764	0.602	0.220	0.684	0.081	0.868	0.272	0.987	0.802
73	0.654	0.995	0.073	0.655	0.041	0.811	0.367	0.226	0.438	0.107
74	0.650	0.467	0.210	0.204	0.762	0.420	0.680	0.334	0.723	0.446
75	0.039	0.022	0.823	0.087	0.076	0.568	0.515	0.223	0.561	0.316
76	0.291	0.791	0.788	0.396	0.212	0.138	0.357	0.304	0.575	0.342
77	0.834	0.373	0.584	0.694	0.613	0.817	0.129	0.546	0.425	0.290
78	0.511	0.375	0.048	0.923	0.001	0.088	0.258	0.166	0.787	0.837
79	0.538	0.174	0.068	0.052	0.640	0.148	0.093	0.553	0.565	0.862
80	0.560	0.724	0.975	0.818	0.796	0.379	0.069	0.034	0.792	0.757
81	0.492	0.820	0.489	0.872	0.770	0.991	0.704	0.050	0.874	0.621
82	0.890	0.356	0.451	0.554	0.649	0.507	0.061	0.479	0.211	0.273
83	0.966	0.798	0.917	0.141	0.368	0.193	0.443	0.751	0.458	0.746
84	0.517	0.715	0.777	0.742	0.839	0.307	0.246	0.956	0.665	0.111
85	0.786	0.328	0.015	0.643	0.882	0.815	0.963	0.590	0.855	0.891
86	0.047	0.702	0.287	0.177	0.164	0.552	0.296	0.413	0.941	0.849
87	0.681	0.678	0.563	0.851	0.726	0.801	0.573	0.056	0.140	0.641
88	0.404	0.842	0.412	0.893	0.935	0.744	0.386	0.299	0.178	0.881
89	0.033	0.042	0.753	0.660	0.685	0.171	0.408	0.060	0.550	0.302
90	0.128	0.658	0.667	0.926	0.239	0.127	0.903	0.483	0.300	0.597
91	0.973	0.933	0.361	0.595	0.186	0.901	0.914	0.190	0.303	0.098
92	0.672	0.729	0.163	0.310	0.196	0.964	0.486	0.308	0.735	0.474
93	0.524	0.402	0.628	0.410	0.846	0.206	0.585	0.566	0.044	0.627
94	0.720	0.157	0.238	0.078	0.233	0.771	0.533	0.986	0.077	0.101
95	0.983	0.669	0.927	0.066	0.080	0.740	0.969	0.630	0.619	0.200
96	0.294	0.387	0.988	0.961	0.913	0.679	0.284	0.949	0.380	0.785
97	0.668	0.149	0.972	0.187	0.151	0.502	0.718	0.453	0.953	0.491
98	0.130	0.708	0.417	0.594	0.209	0.663	0.908	0.271	0.532	0.741
99	0.883	0.677	0.615	0.469	0.363	0.142	0.952	0.325	0.194	0.847
100	0.889	0.772	0.390	0.571	0.873	0.806	0.448	0.955	0.240	0.074